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Results for Additional Calculations for Task Order 98-009B-01, Addendum to: HNF-SD-SNF-CSER- 005, Revision 3

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Abstract: Several sets of new calculations were performed to support the Spent Nuclear Fuel project nuclear criticality safety evaluation. These new calculations include partial loading of Mark IA inner elements after the outers have been loaded, a new, more robust design for the central pipe insert for the Mark IA fuel baskets, Single Pass Reactor fuel loading, the lowering of a Mark IV-loaded MCO through the concrete operating deck as it is inserted into the Canister Storage Building storage array, and one additional scrap basket loading error. None of these calculations exceeded the criticality safety limit.

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CHECKLIST FOR INDEPENDENT TECHNICAL REVIEW

DOCUMENT REVIEWED

NUMBER: HNF-SD-SNF-CSER-005, Rev. 3, Add. 3TITLE: Results for Additional Calculations for Task Order 98-0009B-01AUTHOR(s): Kevin N. Schwinkendorf

I. Method(s) of Review

- ☐ (Y) Input data checked for accuracy
☐ (N) Independent calculation performed
 ☐ () Hand calculation
 ☐ () Alternate computer code: _____
☐ (Y) Comparison to experiment or previous results
☐ () Alternate method (define) _____

II. Checklist (either check or enter NA if not applied)

- ☐ (Y) Task completely defined
☐ (Y) Activity consistent with task specification
☐ (Y) Necessary assumptions explicitly stated and supported
☐ (Y) Resources properly identified and referenced
☐ (Y) Resource documentation appropriate for this application
☐ (Y) Input data explicitly stated
☐ (Y) Input data verified to be consistent with original source
☐ (Y) Geometric model adequate representation of actual geometry
☐ (Y) Material properties appropriate and reasonable
☐ (NA) Mathematical derivations checked including dimensional consistency
☐ (NA) Hand calculations checked for errors
☐ (Y) Assumptions explicitly stated and justified
☐ (Y) Computer software appropriate for task and used within range of validity
☐ (NA) Use of resource outside range of established validity is justified
☐ (Y) Software runstreams correct and consistent with results
☐ (Y) Software output consistent with input
☐ (Y) Results consistent with applicable previous experimental or analytical findings
☐ (Y) Results and conclusions address all points and are consistent with task requirements and/or established limits or criteria
☐ (Y) Conclusions consistent with analytical results and established limits
☐ (Y) Uncertainty assessment appropriate and reasonable
☐ () Other (define) _____

III. Comments:

V. REVIEWER: Warren D. Wittekind DATE: 6 November 1997

RESULTS FOR ADDITIONAL CALCULATIONS FOR TASK ORDER 98-009B-01, ADDENDUM 3 TO: HNF-SD-SNF-CSER-005, REVISION 3

Methodology

The Monte Carlo N-Particle (MCNP) (Breisemeister 1993) computer code was used to perform the three-dimensional calculations documented in this report. MCNP was used to perform Monte Carlo simulations of the transport of neutrons through several models of the Multicanister Overpack (MCO) container to obtain statistical estimates of the effective neutron multiplication factor, k_{eff} . The WIMS-E (Gubbins, et al. 1982) lattice physics computer code was used to perform parametric variations of spacing of Single-Pass Reactor (SPR) fuel in water to determine optimal spacing for maximum reactivity. These results were used in the MCNP models which include optimally spaced SPR fuel.

Assumptions

MCNP calculations case1 and case2 (Schwinkendorf 1997) are the nominal, intact, as-loaded configurations for the MCOs, still fully-flooded with water. MCNP calculations case3 and case4 are the drop accident models. Intact fuel is replaced with rubble, defined as the most reactive lattice possible with a fuel packing fraction of 0.4, and the radial dimensions are expanded. Calculations reported in this report can be divided into five groups:

1. Partial loading of Mark IA inners is treated by removing half of the inners from case1, according to the loading pattern shown in Figure 1. The other half of the inners are removed, as shown in Figure 2, and finally, all inners are removed.
2. The central insert for the Mark IA-loaded MCO has been changed to XXS steel pipe. The inner dimension is therefore reduced. Both case1 and case3 were redone with the new dimension.
3. Explicit models for SPR fuel were required, and so two new models were created, case9 and case9a, which analyze an MCO loaded with all optimized SPR fuel. The enrichment was equal to 0.95 wt% ^{235}U , except for a quantity of 2.1 wt% enriched SPR fuel, which corresponds in mass to the amount of unidentified SPR fuel now in the basin. This higher enrichment is very likely higher than what the fuel really is, but 2.1 wt% is the highest SPR fuel ever used, and so this is a bounding, conservative assumption. Actual dimensions were used, and WIMS-E was used to find the optimal spacing in water to maximize k_{eff} for the two lattices. The higher-enriched SPR fuel was placed near the center of the MCO (in a region of greater neutron importance) to maximize k_{eff} . Figure 3 illustrates the axial geometry of the models. In case9, normal dimensions are used; in case9a, the radially expanded dimensions for the drop accident are used.
4. The case2 model was modified by stripping off the cask from the MCO, which was then inserted into the geometry depicted in Figure 4. The upper steel cylinder is a conservative model for the MCO Handling Machine (MHM). This model analyzes the process of lowering a flooded Mark IV-loaded MCO into the CSB.

5. case1 was recalculated with the upper scrap basket and the intact fuel basket in tier 4 exchanged. This leaves two scrap baskets loaded (tiers 4 and 6), with the remaining tiers filled with intact Mark IA fuel assemblies.

Input Data

Input files for the calculations reside on the core workstation server disk under the directory:

/home/h56712/mcnp

MCNP input files for set 1 are case1i1.inp, case1i2.inp, and case1i3.inp. Input files for set 2 are case1-2.inp and case3-2.inp. The MCNP input files for set 3 are case9 and case9a.inp. WIMS-E input files for set 3 are spr_95 and spr_21. The input file for the one calculation in set 4 is case2_dp.inp. The input file for the one calculation in set 5 is case5c.inp.

Calculations

The MCNP calculations were performed using 50 neutron generations of 1,000 neutron histories per generation, and 10 generations were skipped before statistical information was included in the result. The calculations were performed on the sgi1 Silicon Graphics workstation.

Results

The original results from CSER-005 (models shown in Figure 4-3 in the CSER) are as follows:

case1 (Mark IA):	$k_{\text{eff}} = 0.8721 \pm 0.0030$
case2 (Mark IV):	$k_{\text{eff}} = 0.8824 \pm 0.0022$
case3 (Mark IA):	$k_{\text{eff}} = 0.9104 \pm 0.0027$
case4 (Mark IV):	$k_{\text{eff}} = 0.9341 \pm 0.0028$
case5 (Mark IA):	$k_{\text{eff}} = 0.9016 \pm 0.0030$
case5a (Mark IA):	$k_{\text{eff}} = 0.8784 \pm 0.0041$
case5b (Mark IA):	$k_{\text{eff}} = 0.9031 \pm 0.0034$

These results are in the form $k_{\text{eff}} \pm \sigma$. The new MCNP results are as follows:

set 1: case1i1 (Mark IA):	$k_{\text{eff}} = 0.8780 \pm 0.0038$
case1i2 (Mark IA):	$k_{\text{eff}} = 0.8833 \pm 0.0032$
case1i3 (Mark IA):	$k_{\text{eff}} = 0.8854 \pm 0.0027$
set 2: case1-2 (Mark IA):	$k_{\text{eff}} = 0.8809 \pm 0.0038$
case3-2 (Mark IA):	$k_{\text{eff}} = 0.9130 \pm 0.0030$
set 3: case9 (SPR fuel):	$k_{\text{eff}} = 0.8313 \pm 0.0029$
case9a (SPR fuel):	$k_{\text{eff}} = 0.8499 \pm 0.0033$
set 4: case2_dp (Mark IV):	$k_{\text{eff}} = 0.8892 \pm 0.0029$
set 5: case5c (Mark IA):	$k_{\text{eff}} = 0.8871 \pm 0.0033$

In the first set of calculations, partial loading is addressed. If the Mark IA outers are loaded without any inners, the result would be case1i3, $k_{\text{eff}} = 0.8854$. If only half of the inners are then loaded, as in Figure 1, the result is case1i1, $k_{\text{eff}} = 0.8780$. With only the other half of the inners loaded, as shown in Figure 2, the result is case1i2, $k_{\text{eff}} = 0.8833$. These results show up to 13 mk higher reactivity than case1 from the CSER.

In the second set of calculations, a revised inner diameter was analyzed for the central insert for the Mark IA-loaded MCOs. With the new, thicker insert, case1 increased from 0.8721 to 0.8809. For the drop accident model, case3 increased from 0.9104 to 0.9130.

WIMS-E was used to find the optimal spacing of SPR fuel in water for maximum reactivity. Figure 5 shows the results. The maximum k_{∞} lattice for each SPR fuel type was used in the MCNP models case9 and case9a in set 3 above. These models are conservative in several ways. First, the inventory of SPR fuel elements consists of 779 highly depleted uranium target elements (with ^{235}U content equal to 0.14 wt% in uranium) and 185 other elements. Of these 185 pieces, all are of known origin, except for 47, which are unidentified. All of the 138 identified pieces are bounded by an enrichment of 0.95 wt%, although many are natural (i.e., 0.714 wt%). There is an estimated 8.7 kg of plutonium in the 779 elements (2870 kg) of depleted targets. This results in about 0.3 wt% plutonium in uranium (or about 0.44 wt% fissile content in the uranium targets). In the MCNP models, all of the fuel is modeled as 0.95 wt% ^{235}U enriched SPR fuel, except for the unidentified fuel, which is assumed 2.1 wt%. Secondly, when the volume of all six Mark IA scrap baskets are filled with SPR fuel at optimal spacing, the total inventory is 5467 kg, which is greater than the actual inventory of 3370 kg. The fraction of 2.1 wt% SPR fuel in the MCNP model is the same as the fraction of unidentified SPR fuel in the actual inventory, and so the amount of 2.1 wt% fuel in the MCNP model is greater than the actual unidentified pieces by this same ratio (i.e., $5467/3370 = 1.622$, or 62% more than in the real inventory). Thirdly, the plan is to load the one basket which contains the unidentified SPR fuel into the top location, in a region of reduced neutron importance. As analyzed, this potentially higher enriched fuel was modeled near the center of the MCO, which bounds misloading. Even with all of these conservative assumptions, the k_{eff} is well within the criticality safety limit of 0.95.

The case2 result from the CSER was 0.8824. The effect of removing the 7.5 inches of steel, which models the shipping cask, and inserting the water-flooded Mark IV-loaded MCO into the geometry as shown in Figure 4 was to increase k_{eff} to 0.8892, approximately 7 mk.

The case5c result is another variation on the question of maximum k_{eff} for different scrap basket loading combinations. The case1 result from the CSER has two scrap baskets loaded with optimal 1.25 wt% scrap, placed in the top and bottom locations in the MCO, with four tiers of 48 intact Mark IA assemblies in between. The case5 model places the top scrap basket into level 5, directly above the bottom scrap basket. The k_{eff} is increased from 0.8721 to 0.9016. In case5a, only one scrap basket is loaded, but into tier 4, in a region of higher neutron importance, and so k_{eff} is increased to 0.8784. With two scrap baskets loaded into the center (tiers 3 and 4), analyzed by case5b, the k_{eff} is increased to 0.9031. The new result, case5c, models tiers 4 and 6 loaded with scrap baskets. This result was $k_{\text{eff}} = 0.8871$. The case5c result was less than the case5 result because of reduced neutronic interaction.

Figure 1. Mark IA-Loaded MCO with only Half of the Inners Loaded.

Figure 2. Mark IA-Loaded MCO with the other Half of the Inners Loaded.

Figure 3. MCO Loaded with Single-Pass Reactor Fuel, using Mark IA Scrap Baskets.
Lattice Spacing Optimized using WIMS-E

Figure 4. Water-Flooded, Mark IV-Loaded MCO Being Lowered into a CSB Storage Tube.

Figure 5. Single-Pass Reactor Fuel Elements in Water.
WIMS-E Results for Lattice k_{∞} vs. Spacing.

Conclusions

The MCNP calculations documented in this report addressed five questions raised by reviewers. Partial loading of Mark IA inner into the MCO could increase k_{eff} by about 13 mk, but the result is still well within the criticality safety limit.

The effect of using the newest dimensions for the central insert in the Mark IA basket is to increase k_{eff} by about 8 mk for the normal configuration geometry and 3 mk for the drop accident model. Both of these results are still well within the criticality safety limit.

Loading all of the SPR fuel into one MCO (using all six of the Mark IA scrap baskets) satisfies the criticality safety limit, even under several bounding conservative assumptions.

The geometric configuration with a water-flooded Mark IV-loaded MCO being lowered into a CSB storage tube was modeled and was found to satisfy the criticality safety limit. This model assumed a two-foot radial reflector surrounding the lower 5 feet of the MCO, with the MHM (modeled as 10 inches of steel) surrounding the rest of the MCO. The k_{eff} of this configuration was only 7 mk higher than the k_{eff} of the original case2 result reported in CSER-005.

One last MCNP calculation was performed to find the k_{eff} of a water-flooded Mark IA-loaded MCO, with the top scrap basket misloaded into tier 4. This result was found to satisfy the criticality safety limit.

References

- Breismsister, J. F., Editor, 1993, *MCNP — A General Monte Carlo N-Particle Transport Code, Version 4A*, LA-12625, Los Alamos National Laboratory, Los Alamos, New Mexico.
- Gubbins, M. E., M. J. Roth, and C. J. Taubman, 1982, *A General Introduction to the Use of the WIMS-E Modular Program*, AEEW-R 1329, Reactor Physics Division, AEE Winfrith, England.
- Schwinkendorf, K. N., 1997, *Criticality Safety Evaluation Report for Spent Nuclear Fuel Processing and Storage Facilities*, HNF-SD-SNF-CSER-005 Revision 3, Fluor Daniel Northwest, Richland, Washington.

Sample MCNP input file

The following is a listing of the input file case111.inp, the geometry is depicted in Figure 1:

message:

```
multiple canister over-pack - RUN 1 - Normal MKIA Case
5 4 -1.00 -5 388 -389 u=1 imp:n=1 $ water.....position 1
6 2 -6.55 5 -6 388 -389 u=1 imp:n=1 $ zr clad
7 6 -18.58 6 -7 388 -389 u=1 imp:n=1 $ outer fuel
8 2 -6.55 7 -8 388 -389 u=1 imp:n=1 $ zr clad
13 4 -1.00 -13 388 -389 u=1 imp:n=1 $ water.....position 2
14 2 -6.55 13 -14 388 -389 u=1 imp:n=1 $ zr clad
15 6 -18.58 14 -15 388 -389 u=1 imp:n=1 $ outer fuel
16 2 -6.55 15 -16 388 -389 u=1 imp:n=1 $ zr clad
21 4 -1.00 -21 388 -389 u=1 imp:n=1 $ water.....position 3
22 2 -6.55 21 -22 388 -389 u=1 imp:n=1 $ zr clad
23 6 -18.58 22 -23 388 -389 u=1 imp:n=1 $ outer fuel
24 2 -6.55 23 -24 388 -389 u=1 imp:n=1 $ zr clad
29 4 -1.00 -29 388 -389 u=1 imp:n=1 $ water.....position 4
30 2 -6.55 29 -30 388 -389 u=1 imp:n=1 $ zr clad
31 6 -18.58 30 -31 388 -389 u=1 imp:n=1 $ outer fuel
32 2 -6.55 31 -32 388 -389 u=1 imp:n=1 $ zr clad
37 4 -1.00 -37 388 -389 u=1 imp:n=1 $ water.....position 5
38 2 -6.55 37 -38 388 -389 u=1 imp:n=1 $ zr clad
39 6 -18.58 38 -39 388 -389 u=1 imp:n=1 $ outer fuel
40 2 -6.55 39 -40 388 -389 u=1 imp:n=1 $ zr clad
45 4 -1.00 -45 388 -389 u=1 imp:n=1 $ water.....position 6
46 2 -6.55 45 -46 388 -389 u=1 imp:n=1 $ zr clad
47 6 -18.58 46 -47 388 -389 u=1 imp:n=1 $ outer fuel
48 2 -6.55 47 -48 388 -389 u=1 imp:n=1 $ zr clad
53 4 -1.00 -53 388 -389 u=1 imp:n=1 $ water.....position 7
54 2 -6.55 53 -54 388 -389 u=1 imp:n=1 $ zr clad
55 6 -18.58 54 -55 388 -389 u=1 imp:n=1 $ outer fuel
56 2 -6.55 55 -56 388 -389 u=1 imp:n=1 $ zr clad
61 4 -1.00 -61 388 -389 u=1 imp:n=1 $ water.....position 8
62 2 -6.55 61 -62 388 -389 u=1 imp:n=1 $ zr clad
63 6 -18.58 62 -63 388 -389 u=1 imp:n=1 $ outer fuel
64 2 -6.55 63 -64 388 -389 u=1 imp:n=1 $ zr clad
69 4 -1.00 -69 388 -389 u=1 imp:n=1 $ water.....position 9
70 2 -6.55 69 -70 388 -389 u=1 imp:n=1 $ zr clad
71 6 -18.58 70 -71 388 -389 u=1 imp:n=1 $ outer fuel
72 2 -6.55 71 -72 388 -389 u=1 imp:n=1 $ zr clad
77 4 -1.00 -77 388 -389 u=1 imp:n=1 $ water.....position 10
78 2 -6.55 77 -78 388 -389 u=1 imp:n=1 $ zr clad
79 6 -18.58 78 -79 388 -389 u=1 imp:n=1 $ outer fuel
80 2 -6.55 79 -80 388 -389 u=1 imp:n=1 $ zr clad
85 4 -1.00 -85 388 -389 u=1 imp:n=1 $ water.....position 11
86 2 -6.55 85 -86 388 -389 u=1 imp:n=1 $ zr clad
87 6 -18.58 86 -87 388 -389 u=1 imp:n=1 $ outer fuel
88 2 -6.55 87 -88 388 -389 u=1 imp:n=1 $ zr clad
```

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93 4	-1.00		-93 388	-389 u=1 imp:n=1 \$ water.....position 12
94 2	-6.55	93	-94 388	-389 u=1 imp:n=1 \$ zr clad
95 6	-18.58	94	-95 388	-389 u=1 imp:n=1 \$ outer fuel
96 2	-6.55	95	-96 388	-389 u=1 imp:n=1 \$ zr clad
97 4	-1.00		-97 388	-389 u=1 imp:n=1 \$ inner water.....position 13
98 2	-6.55	97	-98 388	-389 u=1 imp:n=1 \$ zr clad
99 1	-18.58	98	-99 388	-389 u=1 imp:n=1 \$ inner fuel
100 2	-6.55	99	-100 388	-389 u=1 imp:n=1 \$ zr clad
101 4	-1.00	100	-101 388	-389 u=1 imp:n=1 \$ water
102 2	-6.55	101	-102 388	-389 u=1 imp:n=1 \$ zr clad
103 6	-18.58	102	-103 388	-389 u=1 imp:n=1 \$ outer fuel
104 2	-6.55	103	-104 388	-389 u=1 imp:n=1 \$ zr clad
105 4	-1.00		-105 388	-389 u=1 imp:n=1 \$ inner water.....position 14
106 2	-6.55	105	-106 388	-389 u=1 imp:n=1 \$ zr clad
107 1	-18.58	106	-107 388	-389 u=1 imp:n=1 \$ inner fuel
108 2	-6.55	107	-108 388	-389 u=1 imp:n=1 \$ zr clad
109 4	-1.00	108	-109 388	-389 u=1 imp:n=1 \$ water
110 2	-6.55	109	-110 388	-389 u=1 imp:n=1 \$ zr clad
111 6	-18.58	110	-111 388	-389 u=1 imp:n=1 \$ outer fuel
112 2	-6.55	111	-112 388	-389 u=1 imp:n=1 \$ zr clad
113 4	-1.00		-113 388	-389 u=1 imp:n=1 \$ inner water.....position 15
114 2	-6.55	113	-114 388	-389 u=1 imp:n=1 \$ zr clad
115 1	-18.58	114	-115 388	-389 u=1 imp:n=1 \$ inner fuel
116 2	-6.55	115	-116 388	-389 u=1 imp:n=1 \$ zr clad
117 4	-1.00	116	-117 388	-389 u=1 imp:n=1 \$ water
118 2	-6.55	117	-118 388	-389 u=1 imp:n=1 \$ zr clad
119 6	-18.58	118	-119 388	-389 u=1 imp:n=1 \$ outer fuel
120 2	-6.55	119	-120 388	-389 u=1 imp:n=1 \$ zr clad
121 4	-1.00		-121 388	-389 u=1 imp:n=1 \$ inner water.....position 16
122 2	-6.55	121	-122 388	-389 u=1 imp:n=1 \$ zr clad
123 1	-18.58	122	-123 388	-389 u=1 imp:n=1 \$ inner fuel
124 2	-6.55	123	-124 388	-389 u=1 imp:n=1 \$ zr clad
125 4	-1.00	124	-125 388	-389 u=1 imp:n=1 \$ water
126 2	-6.55	125	-126 388	-389 u=1 imp:n=1 \$ zr clad
127 6	-18.58	126	-127 388	-389 u=1 imp:n=1 \$ outer fuel
128 2	-6.55	127	-128 388	-389 u=1 imp:n=1 \$ zr clad
129 4	-1.00		-129 388	-389 u=1 imp:n=1 \$ inner water.....position 17
130 2	-6.55	129	-130 388	-389 u=1 imp:n=1 \$ zr clad
131 1	-18.58	130	-131 388	-389 u=1 imp:n=1 \$ inner fuel
132 2	-6.55	131	-132 388	-389 u=1 imp:n=1 \$ zr clad
133 4	-1.00	132	-133 388	-389 u=1 imp:n=1 \$ water
134 2	-6.55	133	-134 388	-389 u=1 imp:n=1 \$ zr clad
135 6	-18.58	134	-135 388	-389 u=1 imp:n=1 \$ outer fuel
136 2	-6.55	135	-136 388	-389 u=1 imp:n=1 \$ zr clad
137 4	-1.00		-137 388	-389 u=1 imp:n=1 \$ inner water.....position 18
138 2	-6.55	137	-138 388	-389 u=1 imp:n=1 \$ zr clad
139 1	-18.58	138	-139 388	-389 u=1 imp:n=1 \$ inner fuel
140 2	-6.55	139	-140 388	-389 u=1 imp:n=1 \$ zr clad
141 4	-1.00	140	-141 388	-389 u=1 imp:n=1 \$ water
142 2	-6.55	141	-142 388	-389 u=1 imp:n=1 \$ zr clad
143 6	-18.58	142	-143 388	-389 u=1 imp:n=1 \$ outer fuel
144 2	-6.55	143	-144 388	-389 u=1 imp:n=1 \$ zr clad
145 4	-1.00		-145 388	-389 u=1 imp:n=1 \$ inner water.....position 19
146 2	-6.55	145	-146 388	-389 u=1 imp:n=1 \$ zr clad
147 1	-18.58	146	-147 388	-389 u=1 imp:n=1 \$ inner fuel
148 2	-6.55	147	-148 388	-389 u=1 imp:n=1 \$ zr clad
149 4	-1.00	148	-149 388	-389 u=1 imp:n=1 \$ water
150 2	-6.55	149	-150 388	-389 u=1 imp:n=1 \$ zr clad
151 6	-18.58	150	-151 388	-389 u=1 imp:n=1 \$ outer fuel
152 2	-6.55	151	-152 388	-389 u=1 imp:n=1 \$ zr clad
153 4	-1.00		-153 388	-389 u=1 imp:n=1 \$ inner water.....position 20
154 2	-6.55	153	-154 388	-389 u=1 imp:n=1 \$ zr clad
155 1	-18.58	154	-155 388	-389 u=1 imp:n=1 \$ inner fuel
156 2	-6.55	155	-156 388	-389 u=1 imp:n=1 \$ zr clad
157 4	-1.00	156	-157 388	-389 u=1 imp:n=1 \$ water
158 2	-6.55	157	-158 388	-389 u=1 imp:n=1 \$ zr clad
159 6	-18.58	158	-159 388	-389 u=1 imp:n=1 \$ outer fuel
160 2	-6.55	159	-160 388	-389 u=1 imp:n=1 \$ zr clad
161 4	-1.00		-161 388	-389 u=1 imp:n=1 \$ inner water.....position 21
162 2	-6.55	161	-162 388	-389 u=1 imp:n=1 \$ zr clad
163 1	-18.58	162	-163 388	-389 u=1 imp:n=1 \$ inner fuel
164 2	-6.55	163	-164 388	-389 u=1 imp:n=1 \$ zr clad
165 4	-1.00	164	-165 388	-389 u=1 imp:n=1 \$ water
166 2	-6.55	165	-166 388	-389 u=1 imp:n=1 \$ zr clad
167 6	-18.58	166	-167 388	-389 u=1 imp:n=1 \$ outer fuel
168 2	-6.55	167	-168 388	-389 u=1 imp:n=1 \$ zr clad
169 4	-1.00		-169 388	-389 u=1 imp:n=1 \$ inner water.....position 22

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170 2	-6.55	169 -170 388	-389 u=1 imp:n=1 \$	zr clad
171 1	-18.58	170 -171 388	-389 u=1 imp:n=1 \$	inner fuel
172 2	-6.55	171 -172 388	-389 u=1 imp:n=1 \$	zr clad
173 4	-1.00	172 -173 388	-389 u=1 imp:n=1 \$	water
174 2	-6.55	173 -174 388	-389 u=1 imp:n=1 \$	zr clad
175 6	-18.58	174 -175 388	-389 u=1 imp:n=1 \$	outer fuel
176 2	-6.55	175 -176 388	-389 u=1 imp:n=1 \$	zr clad
177 4	-1.00	176 -177 388	-389 u=1 imp:n=1 \$	inner water....position 23
178 2	-6.55	177 -178 388	-389 u=1 imp:n=1 \$	zr clad
179 1	-18.58	178 -179 388	-389 u=1 imp:n=1 \$	inner fuel
180 2	-6.55	179 -180 388	-389 u=1 imp:n=1 \$	zr clad
181 4	-1.00	180 -181 388	-389 u=1 imp:n=1 \$	water
182 2	-6.55	181 -182 388	-389 u=1 imp:n=1 \$	zr clad
183 6	-18.58	182 -183 388	-389 u=1 imp:n=1 \$	outer fuel
184 2	-6.55	183 -184 388	-389 u=1 imp:n=1 \$	zr clad
185 4	-1.00	184 -185 388	-389 u=1 imp:n=1 \$	inner water....position 24
186 2	-6.55	185 -186 388	-389 u=1 imp:n=1 \$	zr clad
187 1	-18.58	186 -187 388	-389 u=1 imp:n=1 \$	inner fuel
188 2	-6.55	187 -188 388	-389 u=1 imp:n=1 \$	zr clad
189 4	-1.00	188 -189 388	-389 u=1 imp:n=1 \$	water
190 2	-6.55	189 -190 388	-389 u=1 imp:n=1 \$	zr clad
191 6	-18.58	190 -191 388	-389 u=1 imp:n=1 \$	outer fuel
192 2	-6.55	191 -192 388	-389 u=1 imp:n=1 \$	zr clad
193 4	-1.00	192 -193 388	-389 u=1 imp:n=1 \$	inner water....position 25
194 2	-6.55	193 -194 388	-389 u=1 imp:n=1 \$	zr clad
195 1	-18.58	194 -195 388	-389 u=1 imp:n=1 \$	inner fuel
196 2	-6.55	195 -196 388	-389 u=1 imp:n=1 \$	zr clad
197 4	-1.00	196 -197 388	-389 u=1 imp:n=1 \$	water
198 2	-6.55	197 -198 388	-389 u=1 imp:n=1 \$	zr clad
199 6	-18.58	198 -199 388	-389 u=1 imp:n=1 \$	outer fuel
200 2	-6.55	199 -200 388	-389 u=1 imp:n=1 \$	zr clad
201 4	-1.00	200 -201 388	-389 u=1 imp:n=1 \$	inner water....position 26
202 2	-6.55	201 -202 388	-389 u=1 imp:n=1 \$	zr clad
203 1	-18.58	202 -203 388	-389 u=1 imp:n=1 \$	inner fuel
204 2	-6.55	203 -204 388	-389 u=1 imp:n=1 \$	zr clad
205 4	-1.00	204 -205 388	-389 u=1 imp:n=1 \$	water
206 2	-6.55	205 -206 388	-389 u=1 imp:n=1 \$	zr clad
207 6	-18.58	206 -207 388	-389 u=1 imp:n=1 \$	outer fuel
208 2	-6.55	207 -208 388	-389 u=1 imp:n=1 \$	zr clad
209 4	-1.00	208 -209 388	-389 u=1 imp:n=1 \$	inner water....position 27
210 2	-6.55	209 -210 388	-389 u=1 imp:n=1 \$	zr clad
211 1	-18.58	210 -211 388	-389 u=1 imp:n=1 \$	inner fuel
212 2	-6.55	211 -212 388	-389 u=1 imp:n=1 \$	zr clad
213 4	-1.00	212 -213 388	-389 u=1 imp:n=1 \$	water
214 2	-6.55	213 -214 388	-389 u=1 imp:n=1 \$	zr clad
215 6	-18.58	214 -215 388	-389 u=1 imp:n=1 \$	outer fuel
216 2	-6.55	215 -216 388	-389 u=1 imp:n=1 \$	zr clad
217 4	-1.00	216 -217 388	-389 u=1 imp:n=1 \$	inner water....position 28
218 2	-6.55	217 -218 388	-389 u=1 imp:n=1 \$	zr clad
219 1	-18.58	218 -219 388	-389 u=1 imp:n=1 \$	inner fuel
220 2	-6.55	219 -220 388	-389 u=1 imp:n=1 \$	zr clad
221 4	-1.00	220 -221 388	-389 u=1 imp:n=1 \$	water
222 2	-6.55	221 -222 388	-389 u=1 imp:n=1 \$	zr clad
223 6	-18.58	222 -223 388	-389 u=1 imp:n=1 \$	outer fuel
224 2	-6.55	223 -224 388	-389 u=1 imp:n=1 \$	zr clad
225 4	-1.00	224 -225 388	-389 u=1 imp:n=1 \$	inner water....position 29
226 2	-6.55	225 -226 388	-389 u=1 imp:n=1 \$	zr clad
227 1	-18.58	226 -227 388	-389 u=1 imp:n=1 \$	inner fuel
228 2	-6.55	227 -228 388	-389 u=1 imp:n=1 \$	zr clad
229 4	-1.00	228 -229 388	-389 u=1 imp:n=1 \$	water
230 2	-6.55	229 -230 388	-389 u=1 imp:n=1 \$	zr clad
231 6	-18.58	230 -231 388	-389 u=1 imp:n=1 \$	outer fuel
232 2	-6.55	231 -232 388	-389 u=1 imp:n=1 \$	zr clad
233 4	-1.00	232 -233 388	-389 u=1 imp:n=1 \$	inner water....position 30
234 2	-6.55	233 -234 388	-389 u=1 imp:n=1 \$	zr clad
235 1	-18.58	234 -235 388	-389 u=1 imp:n=1 \$	inner fuel
236 2	-6.55	235 -236 388	-389 u=1 imp:n=1 \$	zr clad
237 4	-1.00	236 -237 388	-389 u=1 imp:n=1 \$	water
238 2	-6.55	237 -238 388	-389 u=1 imp:n=1 \$	zr clad
239 6	-18.58	238 -239 388	-389 u=1 imp:n=1 \$	outer fuel
240 2	-6.55	239 -240 388	-389 u=1 imp:n=1 \$	zr clad
241 4	-1.00	240 -241 388	-389 u=1 imp:n=1 \$	water....position 31
242 2	-6.55	241 -242 388	-389 u=1 imp:n=1 \$	zr clad
243 1	-18.58	242 -243 388	-389 u=1 imp:n=1 \$	inner fuel
244 2	-6.55	243 -244 388	-389 u=1 imp:n=1 \$	zr clad
245 4	-1.00	244 -245 388	-389 u=1 imp:n=1 \$	inner water....position 32
246 2	-6.55	245 -246 388	-389 u=1 imp:n=1 \$	zr clad

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251 1	-18.58	250 -251 388	-389 u=1 imp:n=1 \$ inner fuel
252 2	-6.55	251 -252 388	-389 u=1 imp:n=1 \$ zr clad
253 4	-1.00	252 -253 388	-389 u=1 imp:n=1 \$ water
254 2	-6.55	253 -254 388	-389 u=1 imp:n=1 \$ zr clad
255 6	-18.58	254 -255 388	-389 u=1 imp:n=1 \$ outer fuel
256 2	-6.55	255 -256 388	-389 u=1 imp:n=1 \$ zr clad
261 4	-1.00	-261 388	-389 u=1 imp:n=1 \$ water.....position 33
262 2	-6.55	261 -262 388	-389 u=1 imp:n=1 \$ zr clad
263 6	-18.58	262 -263 388	-389 u=1 imp:n=1 \$ outer fuel
264 2	-6.55	263 -264 388	-389 u=1 imp:n=1 \$ zr clad
269 4	-1.00	-269 388	-389 u=1 imp:n=1 \$ water.....position 34
270 2	-6.55	269 -270 388	-389 u=1 imp:n=1 \$ zr clad
271 6	-18.58	270 -271 388	-389 u=1 imp:n=1 \$ outer fuel
272 2	-6.55	271 -272 388	-389 u=1 imp:n=1 \$ zr clad
273 4	-1.00	-273 388	-389 u=1 imp:n=1 \$ inner water.....position 35
274 2	-6.55	273 -274 388	-389 u=1 imp:n=1 \$ zr clad
275 1	-18.58	274 -275 388	-389 u=1 imp:n=1 \$ inner fuel
276 2	-6.55	275 -276 388	-389 u=1 imp:n=1 \$ zr clad
277 4	-1.00	276 -277 388	-389 u=1 imp:n=1 \$ water
278 2	-6.55	277 -278 388	-389 u=1 imp:n=1 \$ zr clad
279 6	-18.58	278 -279 388	-389 u=1 imp:n=1 \$ outer fuel
280 2	-6.55	279 -280 388	-389 u=1 imp:n=1 \$ zr clad
285 4	-1.00	-285 388	-389 u=1 imp:n=1 \$ water.....position 36
286 2	-6.55	285 -286 388	-389 u=1 imp:n=1 \$ zr clad
287 6	-18.58	286 -287 388	-389 u=1 imp:n=1 \$ outer fuel
288 2	-6.55	287 -288 388	-389 u=1 imp:n=1 \$ zr clad
293 4	-1.00	-293 388	-389 u=1 imp:n=1 \$ water.....position 37
294 2	-6.55	293 -294 388	-389 u=1 imp:n=1 \$ zr clad
295 6	-18.58	294 -295 388	-389 u=1 imp:n=1 \$ outer fuel
296 2	-6.55	295 -296 388	-389 u=1 imp:n=1 \$ zr clad
297 4	-1.00	-297 388	-389 u=1 imp:n=1 \$ inner water.....position 38
298 2	-6.55	297 -298 388	-389 u=1 imp:n=1 \$ zr clad
299 1	-18.58	298 -299 388	-389 u=1 imp:n=1 \$ inner fuel
300 2	-6.55	299 -300 388	-389 u=1 imp:n=1 \$ zr clad
301 4	-1.00	300 -301 388	-389 u=1 imp:n=1 \$ water
302 2	-6.55	301 -302 388	-389 u=1 imp:n=1 \$ zr clad
303 6	-18.58	302 -303 388	-389 u=1 imp:n=1 \$ outer fuel
304 2	-6.55	303 -304 388	-389 u=1 imp:n=1 \$ zr clad
309 4	-1.00	-309 388	-389 u=1 imp:n=1 \$ water.....position 39
310 2	-6.55	309 -310 388	-389 u=1 imp:n=1 \$ zr clad
311 6	-18.58	310 -311 388	-389 u=1 imp:n=1 \$ outer fuel
312 2	-6.55	311 -312 388	-389 u=1 imp:n=1 \$ zr clad
317 4	-1.00	-317 388	-389 u=1 imp:n=1 \$ water.....position 40
318 2	-6.55	317 -318 388	-389 u=1 imp:n=1 \$ zr clad
319 6	-18.58	318 -319 388	-389 u=1 imp:n=1 \$ outer fuel
320 2	-6.55	319 -320 388	-389 u=1 imp:n=1 \$ zr clad
321 4	-1.00	-321 388	-389 u=1 imp:n=1 \$ inner water.....position 41
322 2	-6.55	321 -322 388	-389 u=1 imp:n=1 \$ zr clad
323 1	-18.58	322 -323 388	-389 u=1 imp:n=1 \$ inner fuel
324 2	-6.55	323 -324 388	-389 u=1 imp:n=1 \$ zr clad
325 4	-1.00	324 -325 388	-389 u=1 imp:n=1 \$ water
326 2	-6.55	325 -326 388	-389 u=1 imp:n=1 \$ zr clad
327 6	-18.58	326 -327 388	-389 u=1 imp:n=1 \$ outer fuel
328 2	-6.55	327 -328 388	-389 u=1 imp:n=1 \$ zr clad
333 4	-1.00	-333 388	-389 u=1 imp:n=1 \$ water.....position 42
334 2	-6.55	333 -334 388	-389 u=1 imp:n=1 \$ zr clad
335 6	-18.58	334 -335 388	-389 u=1 imp:n=1 \$ outer fuel
336 2	-6.55	335 -336 388	-389 u=1 imp:n=1 \$ zr clad
341 4	-1.00	-341 388	-389 u=1 imp:n=1 \$ water.....position 43
342 2	-6.55	341 -342 388	-389 u=1 imp:n=1 \$ zr clad
343 6	-18.58	342 -343 388	-389 u=1 imp:n=1 \$ outer fuel
344 2	-6.55	343 -344 388	-389 u=1 imp:n=1 \$ zr clad
345 4	-1.00	-345 388	-389 u=1 imp:n=1 \$ inner water.....position 44
346 2	-6.55	345 -346 388	-389 u=1 imp:n=1 \$ zr clad
347 1	-18.58	346 -347 388	-389 u=1 imp:n=1 \$ inner fuel
348 2	-6.55	347 -348 388	-389 u=1 imp:n=1 \$ zr clad
349 4	-1.00	348 -349 388	-389 u=1 imp:n=1 \$ water
350 2	-6.55	349 -350 388	-389 u=1 imp:n=1 \$ zr clad
351 6	-18.58	350 -351 388	-389 u=1 imp:n=1 \$ outer fuel
352 2	-6.55	351 -352 388	-389 u=1 imp:n=1 \$ zr clad
357 4	-1.00	-357 388	-389 u=1 imp:n=1 \$ water.....position 45
358 2	-6.55	357 -358 388	-389 u=1 imp:n=1 \$ zr clad
359 6	-18.58	358 -359 388	-389 u=1 imp:n=1 \$ outer fuel
360 2	-6.55	359 -360 388	-389 u=1 imp:n=1 \$ zr clad
365 4	-1.00	-365 388	-389 u=1 imp:n=1 \$ water.....position 46
366 2	-6.55	365 -366 388	-389 u=1 imp:n=1 \$ zr clad
367 6	-18.58	366 -367 388	-389 u=1 imp:n=1 \$ outer fuel

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368	2	-6.55	367	-368	388	-389	u=1	imp:n=1	\$	zr	clad		
369	4	-1.00		-369	388	-389	u=1	imp:n=1	\$	inner	water.....position 47		
370	2	-6.55	369	-370	388	-389	u=1	imp:n=1	\$	zr	clad		
371	1	-18.58	370	-371	388	-389	u=1	imp:n=1	\$	inner	fuel		
372	2	-6.55	371	-372	388	-389	u=1	imp:n=1	\$	zr	clad		
373	4	-1.00	372	-373	388	-389	u=1	imp:n=1	\$	water			
374	2	-6.55	373	-374	388	-389	u=1	imp:n=1	\$	zr	clad		
375	6	-18.58	374	-375	388	-389	u=1	imp:n=1	\$	outer	fuel		
376	2	-6.55	375	-376	388	-389	u=1	imp:n=1	\$	zr	clad		
381	4	-1.00		-381	388	-389	u=1	imp:n=1	\$	water.....position 48			
382	2	-6.55	381	-382	388	-389	u=1	imp:n=1	\$	zr	clad		
383	6	-18.58	382	-383	388	-389	u=1	imp:n=1	\$	outer	fuel		
384	2	-6.55	383	-384	388	-389	u=1	imp:n=1	\$	zr	clad		
385	4	-1.00	-385		388	-389							
			8	16	24	32	40						
			48	56	64	72	80						
			88	96	104	112	120						
			128	136	144	152	160						
			168	176	184	192	200						
			208	216	224	232	240						
			248	256	264	272	280						
			288	296	304	312	320						
			328	336	344	352	360						
			368	376	384	386							
386	3	-8.03	387	-386	388	-389				u=1	imp:n=1	\$	water
387	4	-1.00	-387		388	-389				u=1	imp:n=1	\$	ss insert
388	6	-18.82	-390							u=1	imp:n=1	\$	water inside ss
389	2	-6.55	390	-391						u=2	imp:n=1	\$	fuel scrap
390	4	-1.00	391							u=2	imp:n=1	\$	fuel clad
391	0	-392	393	-396	395	-394	397	lat=2		u=3	fill=2	imp:n=1	
392	4	-1.00	-404	405	-401					imp:n=1	\$	top	water reflector
393	0	-398	-405	406	402			fill=3		imp:n=1	\$	scrap	in basket #1
394	3	-8.03	-405	407	-402	403				imp:n=1	\$	ss insert	in basket #1
395	4	-1.00	-405	407	-403					imp:n=1	\$	water inside ss insert	
396	3	-8.03	-406	407	-398	402				imp:n=1	\$	ss plate	#1
397	4	-1.00	-407	408	-424	402				imp:n=1	\$	water in gap	#2
398	3	-8.03	-407	408	-402	403				imp:n=1	\$	ss insert in gap	#2
399	4	-1.00	-407	408	-403					imp:n=1	\$	water inside ss insert	
400	0	-424	-408	409				fill=1		imp:n=1	\$	intact fuel -	#2
401	3	-8.03	-409	410	-424	402				imp:n=1	\$	ss plate	#2
402	4	-1.00	-410	411	-424	402				imp:n=1	\$	water in gap	#3
403	3	-8.03	-409	411	-402	403				imp:n=1	\$	ss insert in gap	#3
404	4	-1.00	-409	411	-403					imp:n=1	\$	water inside ss insert	
405	0	-424	-411	412				fill=1		imp:n=1	\$	intact fuel -	#3
406	3	-8.03	-412	413	-424	402				imp:n=1	\$	ss plate	#3
407	4	-1.00	-413	414	-424	402				imp:n=1	\$	water in gap	#4
408	3	-8.03	-412	414	-402	403				imp:n=1	\$	ss insert in gap	#4
409	4	-1.00	-412	414	-403					imp:n=1	\$	water inside ss insert	
410	0	-424	-414	415				fill=1		imp:n=1	\$	intact fuel -	#4
411	3	-8.03	-415	416	-424	402				imp:n=1	\$	ss plate	#4
412	4	-1.00	-416	417	-424	402				imp:n=1	\$	water in gap	#5
413	3	-8.03	-415	417	-402	403				imp:n=1	\$	ss insert in gap	#5
414	4	-1.00	-415	417	-403					imp:n=1	\$	water inside ss insert	
415	0	-424	-417	418				fill=1		imp:n=1	\$	intact fuel -	#5
416	3	-8.03	-418	419	-424	402				imp:n=1	\$	ss plate	#5
417	3	-8.03	-418	419	-402	403				imp:n=1	\$	ss insert in gap	#4
418	4	-1.00	-418	419	-403					imp:n=1	\$	water inside ss insert	
419	0	-398	-419	420	402			fill=3		imp:n=1	\$	scrap in basket	#6
420	3	-8.03	-419	421	-402	403				imp:n=1	\$	ss insert in basket	#6
421	4	-1.00	-419	421	-403					imp:n=1	\$	water inside ss insert	
422	3	-8.03	-420	421	-424	402				imp:n=1	\$	ss plate	#6
423	3	-8.03	-421	422	-400					imp:n=1	\$	ss mco bottom end cap	
424	3	-8.03	398	-424	-405	407				imp:n=1	\$	side of top steel basket	
425	3	-8.03	398	-424	-419	420				imp:n=1	\$	side of bottom basket	
426	3	-8.03	425	-400	-405	421				imp:n=1	\$	steel on side of mco	
427	4	-1.00	400	-401	-405	422				imp:n=1	\$	water surrounding mco	
428	4	-1.00	-422	423	-401					imp:n=1	\$	water below ss end cap	
429	3	-8.03	424	-399	-405	421				imp:n=1	\$	mco liner	
430	4	-1.00	399	-425	-405	421				imp:n=1	\$	water gap	
431	0		404	-423	401					imp:n=0	\$	outside world	
5	c/z	10.66800	6.15917	2.2403						\$	water region.....position 1		
6	c/z	10.66800	6.15917	2.2962						\$	cladding		
7	c/z	10.66800	6.15917	2.9896						\$	outer fuel		
8	c/z	10.66800	6.15917	3.0531						\$	cladding		
13	c/z	7.11200	12.31835	2.2403						\$	water region.....position 2		
14	c/z	7.11200	12.31835	2.2962						\$	cladding		

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15	c/z	7.11200	12.31835	2.9896	\$ outer fuel
16	c/z	7.11200	12.31835	3.0531	\$ cladding
21	c/z	.00000	12.31835	2.2403	\$ water region.....position 3
22	c/z	.00000	12.31835	2.2962	\$ cladding
23	c/z	.00000	12.31835	2.9896	\$ outer fuel
24	c/z	.00000	12.31835	3.0531	\$ cladding
29	c/z	-7.11200	12.31835	2.2403	\$ water region.....position 4
30	c/z	-7.11200	12.31835	2.2962	\$ cladding
31	c/z	-7.11200	12.31835	2.9896	\$ outer fuel
32	c/z	-7.11200	12.31835	3.0531	\$ cladding
37	c/z	-10.66800	6.15917	2.2403	\$ water region.....position 5
38	c/z	-10.66800	6.15917	2.2962	\$ cladding
39	c/z	-10.66800	6.15917	2.9896	\$ outer fuel
40	c/z	-10.66800	6.15917	3.0531	\$ cladding
45	c/z	-14.22400	.00000	2.2403	\$ water region.....position 6
46	c/z	-14.22400	.00000	2.2962	\$ cladding
47	c/z	-14.22400	.00000	2.9896	\$ outer fuel
48	c/z	-14.22400	.00000	3.0531	\$ cladding
53	c/z	-10.66800	-6.15917	2.2403	\$ water region.....position 7
54	c/z	-10.66800	-6.15917	2.2962	\$ cladding
55	c/z	-10.66800	-6.15917	2.9896	\$ outer fuel
56	c/z	-10.66800	-6.15917	3.0531	\$ cladding
61	c/z	-7.11200	-12.31835	2.2403	\$ water region.....position 8
62	c/z	-7.11200	-12.31835	2.2962	\$ cladding
63	c/z	-7.11200	-12.31835	2.9896	\$ outer fuel
64	c/z	-7.11200	-12.31835	3.0531	\$ cladding
69	c/z	.00000	-12.31835	2.2403	\$ water region.....position 9
70	c/z	.00000	-12.31835	2.2962	\$ cladding
71	c/z	.00000	-12.31835	2.9896	\$ outer fuel
72	c/z	.00000	-12.31835	3.0531	\$ cladding
77	c/z	7.11200	-12.31835	2.2403	\$ water region.....position 10
78	c/z	7.11200	-12.31835	2.2962	\$ cladding
79	c/z	7.11200	-12.31835	2.9896	\$ outer fuel
80	c/z	7.11200	-12.31835	3.0531	\$ cladding
85	c/z	10.66800	-6.15917	2.2403	\$ water region.....position 11
86	c/z	10.66800	-6.15917	2.2962	\$ cladding
87	c/z	10.66800	-6.15917	2.9896	\$ outer fuel
88	c/z	10.66800	-6.15917	3.0531	\$ cladding
93	c/z	14.22400	.00000	2.2403	\$ water region.....position 12
94	c/z	14.22400	.00000	2.2962	\$ cladding
95	c/z	14.22400	.00000	2.9896	\$ outer fuel
96	c/z	14.22400	.00000	3.0531	\$ cladding
97	c/z	17.78000	6.15917	0.5588	\$ inner water.....position 13
98	c/z	17.78000	6.15917	0.6223	\$ cladding
99	c/z	17.78000	6.15917	1.4808	\$ inner fuel
100	c/z	17.78000	6.15917	1.5824	\$ cladding
101	c/z	17.78000	6.15917	2.2403	\$ water region
102	c/z	17.78000	6.15917	2.2962	\$ cladding
103	c/z	17.78000	6.15917	2.9896	\$ outer fuel
104	c/z	17.78000	6.15917	3.0531	\$ cladding
105	c/z	14.22400	12.31835	0.5588	\$ inner water.....position 14
106	c/z	14.22400	12.31835	0.6223	\$ cladding
107	c/z	14.22400	12.31835	1.4808	\$ inner fuel
108	c/z	14.22400	12.31835	1.5824	\$ cladding
109	c/z	14.22400	12.31835	2.2403	\$ water region
110	c/z	14.22400	12.31835	2.2962	\$ cladding
111	c/z	14.22400	12.31835	2.9896	\$ outer fuel
112	c/z	14.22400	12.31835	3.0531	\$ cladding
113	c/z	10.66800	18.47752	0.5588	\$ inner water.....position 15
114	c/z	10.66800	18.47752	0.6223	\$ cladding
115	c/z	10.66800	18.47752	1.4808	\$ inner fuel
116	c/z	10.66800	18.47752	1.5824	\$ cladding
117	c/z	10.66800	18.47752	2.2403	\$ water region
118	c/z	10.66800	18.47752	2.2962	\$ cladding
119	c/z	10.66800	18.47752	2.9896	\$ outer fuel
120	c/z	10.66800	18.47752	3.0531	\$ cladding
121	c/z	3.55600	18.47752	0.5588	\$ inner water.....position 16
122	c/z	3.55600	18.47752	0.6223	\$ cladding
123	c/z	3.55600	18.47752	1.4808	\$ inner fuel
124	c/z	3.55600	18.47752	1.5824	\$ cladding
125	c/z	3.55600	18.47752	2.2403	\$ water region
126	c/z	3.55600	18.47752	2.2962	\$ cladding
127	c/z	3.55600	18.47752	2.9896	\$ outer fuel
128	c/z	3.55600	18.47752	3.0531	\$ cladding
129	c/z	-3.55600	18.47752	0.5588	\$ inner water.....position 17
130	c/z	-3.55600	18.47752	0.6223	\$ cladding
131	c/z	-3.55600	18.47752	1.4808	\$ inner fuel

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132	c/z	-3.55600	18.47752	1.5824	\$ cladding
133	c/z	-3.55600	18.47752	2.2403	\$ water region
134	c/z	-3.55600	18.47752	2.2962	\$ cladding
135	c/z	-3.55600	18.47752	2.9896	\$ outer fuel
136	c/z	-3.55600	18.47752	3.0531	\$ cladding
137	c/z	-10.66800	18.47752	0.5588	\$ inner water.....position 18
138	c/z	-10.66800	18.47752	0.6223	\$ cladding
139	c/z	-10.66800	18.47752	1.4808	\$ inner fuel
140	c/z	-10.66800	18.47752	1.5824	\$ cladding
141	c/z	-10.66800	18.47752	2.2403	\$ water region
142	c/z	-10.66800	18.47752	2.2962	\$ cladding
143	c/z	-10.66800	18.47752	2.9896	\$ outer fuel
144	c/z	-10.66800	18.47752	3.0531	\$ cladding
145	c/z	-14.22400	12.31835	0.5588	\$ inner water.....position 19
146	c/z	-14.22400	12.31835	0.6223	\$ cladding
147	c/z	-14.22400	12.31835	1.4808	\$ inner fuel
148	c/z	-14.22400	12.31835	1.5824	\$ cladding
149	c/z	-14.22400	12.31835	2.2403	\$ water region
150	c/z	-14.22400	12.31835	2.2962	\$ cladding
151	c/z	-14.22400	12.31835	2.9896	\$ outer fuel
152	c/z	-14.22400	12.31835	3.0531	\$ cladding
153	c/z	-17.78000	6.15918	0.5588	\$ inner water.....position 20
154	c/z	-17.78000	6.15918	0.6223	\$ cladding
155	c/z	-17.78000	6.15918	1.4808	\$ inner fuel
156	c/z	-17.78000	6.15918	1.5824	\$ cladding
157	c/z	-17.78000	6.15918	2.2403	\$ water region
158	c/z	-17.78000	6.15918	2.2962	\$ cladding
159	c/z	-17.78000	6.15918	2.9896	\$ outer fuel
160	c/z	-17.78000	6.15918	3.0531	\$ cladding
161	c/z	-21.33600	.00000	0.5588	\$ inner water.....position 21
162	c/z	-21.33600	.00000	0.6223	\$ cladding
163	c/z	-21.33600	.00000	1.4808	\$ inner fuel
164	c/z	-21.33600	.00000	1.5824	\$ cladding
165	c/z	-21.33600	.00000	2.2403	\$ water region
166	c/z	-21.33600	.00000	2.2962	\$ cladding
167	c/z	-21.33600	.00000	2.9896	\$ outer fuel
168	c/z	-21.33600	.00000	3.0531	\$ cladding
169	c/z	-17.78000	-6.15917	0.5588	\$ inner water.....position 22
170	c/z	-17.78000	-6.15917	0.6223	\$ cladding
171	c/z	-17.78000	-6.15917	1.4808	\$ inner fuel
172	c/z	-17.78000	-6.15917	1.5824	\$ cladding
173	c/z	-17.78000	-6.15917	2.2403	\$ water region
174	c/z	-17.78000	-6.15917	2.2962	\$ cladding
175	c/z	-17.78000	-6.15917	2.9896	\$ outer fuel
176	c/z	-17.78000	-6.15917	3.0531	\$ cladding
177	c/z	-14.22400	-12.31834	0.5588	\$ inner water.....position 23
178	c/z	-14.22400	-12.31834	0.6223	\$ cladding
179	c/z	-14.22400	-12.31834	1.4808	\$ inner fuel
180	c/z	-14.22400	-12.31834	1.5824	\$ cladding
181	c/z	-14.22400	-12.31834	2.2403	\$ water region
182	c/z	-14.22400	-12.31834	2.2962	\$ cladding
183	c/z	-14.22400	-12.31834	2.9896	\$ outer fuel
184	c/z	-14.22400	-12.31834	3.0531	\$ cladding
185	c/z	-10.66800	-18.47751	0.5588	\$ inner water.....position 24
186	c/z	-10.66800	-18.47751	0.6223	\$ cladding
187	c/z	-10.66800	-18.47751	1.4808	\$ inner fuel
188	c/z	-10.66800	-18.47751	1.5824	\$ cladding
189	c/z	-10.66800	-18.47751	2.2403	\$ water region
190	c/z	-10.66800	-18.47751	2.2962	\$ cladding
191	c/z	-10.66800	-18.47751	2.9896	\$ outer fuel
192	c/z	-10.66800	-18.47751	3.0531	\$ cladding
193	c/z	-3.55601	-18.47752	0.5588	\$ inner water.....position 25
194	c/z	-3.55601	-18.47752	0.6223	\$ cladding
195	c/z	-3.55601	-18.47752	1.4808	\$ inner fuel
196	c/z	-3.55601	-18.47752	1.5824	\$ cladding
197	c/z	-3.55601	-18.47752	2.2403	\$ water region
198	c/z	-3.55601	-18.47752	2.2962	\$ cladding
199	c/z	-3.55601	-18.47752	2.9896	\$ outer fuel
200	c/z	-3.55601	-18.47752	3.0531	\$ cladding
201	c/z	3.55599	-18.47752	0.5588	\$ inner water.....position 26
202	c/z	3.55599	-18.47752	0.6223	\$ cladding
203	c/z	3.55599	-18.47752	1.4808	\$ inner fuel
204	c/z	3.55599	-18.47752	1.5824	\$ cladding
205	c/z	3.55599	-18.47752	2.2403	\$ water region
206	c/z	3.55599	-18.47752	2.2962	\$ cladding
207	c/z	3.55599	-18.47752	2.9896	\$ outer fuel
208	c/z	3.55599	-18.47752	3.0531	\$ cladding

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209	c/z	10.66799	-18.47752	0.5588	\$ inner water.....position 27
210	c/z	10.66799	-18.47752	0.6223	\$ cladding
211	c/z	10.66799	-18.47752	1.4808	\$ inner fuel
212	c/z	10.66799	-18.47752	1.5824	\$ cladding
213	c/z	10.66799	-18.47752	2.2403	\$ water region
214	c/z	10.66799	-18.47752	2.2962	\$ cladding
215	c/z	10.66799	-18.47752	2.9896	\$ outer fuel
216	c/z	10.66799	-18.47752	3.0531	\$ cladding
217	c/z	14.22399	-12.31835	0.5588	\$ inner water.....position 28
218	c/z	14.22399	-12.31835	0.6223	\$ cladding
219	c/z	14.22399	-12.31835	1.4808	\$ inner fuel
220	c/z	14.22399	-12.31835	1.5824	\$ cladding
221	c/z	14.22399	-12.31835	2.2403	\$ water region
222	c/z	14.22399	-12.31835	2.2962	\$ cladding
223	c/z	14.22399	-12.31835	2.9896	\$ outer fuel
224	c/z	14.22399	-12.31835	3.0531	\$ cladding
225	c/z	17.78000	-6.15918	0.5588	\$ inner water.....position 29
226	c/z	17.78000	-6.15918	0.6223	\$ cladding
227	c/z	17.78000	-6.15918	1.4808	\$ inner fuel
228	c/z	17.78000	-6.15918	1.5824	\$ cladding
229	c/z	17.78000	-6.15918	2.2403	\$ water region
230	c/z	17.78000	-6.15918	2.2962	\$ cladding
231	c/z	17.78000	-6.15918	2.9896	\$ outer fuel
232	c/z	17.78000	-6.15918	3.0531	\$ cladding
233	c/z	21.33600	-.00002	0.5588	\$ inner water.....position 30
234	c/z	21.33600	-.00002	0.6223	\$ cladding
235	c/z	21.33600	-.00002	1.4808	\$ inner fuel
236	c/z	21.33600	-.00002	1.5824	\$ cladding
237	c/z	21.33600	-.00002	2.2403	\$ water region
238	c/z	21.33600	-.00002	2.2962	\$ cladding
239	c/z	21.33600	-.00002	2.9896	\$ outer fuel
240	c/z	21.33600	-.00002	3.0531	\$ cladding
245	c/z	24.89200	6.15917	2.2403	\$ water region.....position 31
246	c/z	24.89200	6.15917	2.2962	\$ cladding
247	c/z	24.89200	6.15917	2.9896	\$ outer fuel
248	c/z	24.89200	6.15917	3.0531	\$ cladding
249	c/z	21.33600	12.31835	0.5588	\$ inner water.....position 32
250	c/z	21.33600	12.31835	0.6223	\$ cladding
251	c/z	21.33600	12.31835	1.4808	\$ inner fuel
252	c/z	21.33600	12.31835	1.5824	\$ cladding
253	c/z	21.33600	12.31835	2.2403	\$ water region
254	c/z	21.33600	12.31835	2.2962	\$ cladding
255	c/z	21.33600	12.31835	2.9896	\$ outer fuel
256	c/z	21.33600	12.31835	3.0531	\$ cladding
261	c/z	17.78000	18.47752	2.2403	\$ water region.....position 33
262	c/z	17.78000	18.47752	2.2962	\$ cladding
263	c/z	17.78000	18.47752	2.9896	\$ outer fuel
264	c/z	17.78000	18.47752	3.0531	\$ cladding
269	c/z	7.11200	24.63669	2.2403	\$ water region.....position 34
270	c/z	7.11200	24.63669	2.2962	\$ cladding
271	c/z	7.11200	24.63669	2.9896	\$ outer fuel
272	c/z	7.11200	24.63669	3.0531	\$ cladding
273	c/z	.00000	24.63669	0.5588	\$ inner water.....position 35
274	c/z	.00000	24.63669	0.6223	\$ cladding
275	c/z	.00000	24.63669	1.4808	\$ inner fuel
276	c/z	.00000	24.63669	1.5824	\$ cladding
277	c/z	.00000	24.63669	2.2403	\$ water region
278	c/z	.00000	24.63669	2.2962	\$ cladding
279	c/z	.00000	24.63669	2.9896	\$ outer fuel
280	c/z	.00000	24.63669	3.0531	\$ cladding
285	c/z	-7.11200	24.63669	2.2403	\$ water region.....position 36
286	c/z	-7.11200	24.63669	2.2962	\$ cladding
287	c/z	-7.11200	24.63669	2.9896	\$ outer fuel
288	c/z	-7.11200	24.63669	3.0531	\$ cladding
293	c/z	-17.78000	18.47752	2.2403	\$ water region.....position 37
294	c/z	-17.78000	18.47752	2.2962	\$ cladding
295	c/z	-17.78000	18.47752	2.9896	\$ outer fuel
296	c/z	-17.78000	18.47752	3.0531	\$ cladding
297	c/z	-21.33600	12.31835	0.5588	\$ inner water.....position 38
298	c/z	-21.33600	12.31835	0.6223	\$ cladding
299	c/z	-21.33600	12.31835	1.4808	\$ inner fuel
300	c/z	-21.33600	12.31835	1.5824	\$ cladding
301	c/z	-21.33600	12.31835	2.2403	\$ water region
302	c/z	-21.33600	12.31835	2.2962	\$ cladding
303	c/z	-21.33600	12.31835	2.9896	\$ outer fuel
304	c/z	-21.33600	12.31835	3.0531	\$ cladding
309	c/z	-24.89200	6.15918	2.2403	\$ water region.....position 39

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310	c/z	-24.89200	6.15918	2.2962	\$ cladding
311	c/z	-24.89200	6.15918	2.9896	\$ outer fuel
312	c/z	-24.89200	6.15918	3.0531	\$ cladding
317	c/z	-24.89200	-6.15917	2.2403	\$ water region.....position 40
318	c/z	-24.89200	-6.15917	2.2962	\$ cladding
319	c/z	-24.89200	-6.15917	2.9896	\$ outer fuel
320	c/z	-24.89200	-6.15917	3.0531	\$ cladding
321	c/z	-21.33600	-12.31834	0.5588	\$ inner water.....position 41
322	c/z	-21.33600	-12.31834	0.6223	\$ cladding
323	c/z	-21.33600	-12.31834	1.4808	\$ inner fuel
324	c/z	-21.33600	-12.31834	1.5824	\$ cladding
325	c/z	-21.33600	-12.31834	2.2403	\$ water region
326	c/z	-21.33600	-12.31834	2.2962	\$ cladding
327	c/z	-21.33600	-12.31834	2.9896	\$ outer fuel
328	c/z	-21.33600	-12.31834	3.0531	\$ cladding
333	c/z	-17.78000	-18.47751	2.2403	\$ water region.....position 42
334	c/z	-17.78000	-18.47751	2.2962	\$ cladding
335	c/z	-17.78000	-18.47751	2.9896	\$ outer fuel
336	c/z	-17.78000	-18.47751	3.0531	\$ cladding
341	c/z	-7.11201	-24.63669	2.2403	\$ water region.....position 43
342	c/z	-7.11201	-24.63669	2.2962	\$ cladding
343	c/z	-7.11201	-24.63669	2.9896	\$ outer fuel
344	c/z	-7.11201	-24.63669	3.0531	\$ cladding
345	c/z	-0.00001	-24.63669	0.5588	\$ inner water.....position 44
346	c/z	-0.00001	-24.63669	0.6223	\$ cladding
347	c/z	-0.00001	-24.63669	1.4808	\$ inner fuel
348	c/z	-0.00001	-24.63669	1.5824	\$ cladding
349	c/z	-0.00001	-24.63669	2.2403	\$ water region
350	c/z	-0.00001	-24.63669	2.2962	\$ cladding
351	c/z	-0.00001	-24.63669	2.9896	\$ outer fuel
352	c/z	-0.00001	-24.63669	3.0531	\$ cladding
357	c/z	7.11199	-24.63669	2.2403	\$ water region.....position 45
358	c/z	7.11199	-24.63669	2.2962	\$ cladding
359	c/z	7.11199	-24.63669	2.9896	\$ outer fuel
360	c/z	7.11199	-24.63669	3.0531	\$ cladding
365	c/z	17.77999	-18.47753	2.2403	\$ water region.....position 46
366	c/z	17.77999	-18.47753	2.2962	\$ cladding
367	c/z	17.77999	-18.47753	2.9896	\$ outer fuel
368	c/z	17.77999	-18.47753	3.0531	\$ cladding
369	c/z	21.33599	-12.31836	0.5588	\$ inner water.....position 47
370	c/z	21.33599	-12.31836	0.6223	\$ cladding
371	c/z	21.33599	-12.31836	1.4808	\$ inner fuel
372	c/z	21.33599	-12.31836	1.5824	\$ cladding
373	c/z	21.33599	-12.31836	2.2403	\$ water region
374	c/z	21.33599	-12.31836	2.2962	\$ cladding
375	c/z	21.33599	-12.31836	2.9896	\$ outer fuel
376	c/z	21.33599	-12.31836	3.0531	\$ cladding
381	c/z	24.89200	-6.15919	2.2403	\$ water region.....position 48
382	c/z	24.89200	-6.15919	2.2962	\$ cladding
383	c/z	24.89200	-6.15919	2.9896	\$ outer fuel
384	c/z	24.89200	-6.15919	3.0531	\$ cladding
385	cz	29.21001			\$ basket radius 11.375"
386	cz	8.41375			\$ ss insert outer radius
387	cz	7.3025			\$ ss insert inner radius
388	pz	-170.4975			\$ lowest scrap position
389	pz	171.45			\$ highest scrap position
390	cz	0.70			\$ optimum scrap radius
391	cz	0.76268			\$ scrap token clad radius
392	px	1.22848			\$ lattice hexagon planes
393	px	-1.22848			
394	p	-0.57735	1.0	0.0	1.41853
395	p	0.57735	1.0	0.0	-1.41853
396	p	-0.57735	1.0	0.0	1.41853
397	p	0.57735	1.0	0.0	-1.41853
398	cz	28.8925			\$ basket radius 11.375"
399	cz	30.48			\$ mco opening radius 12"
400	cz	50.8			\$ outer steel radius 20"
401	cz	81.28			\$ water outside mco
402	cz	8.41375			\$ ss insert outer radius
403	cz	7.3025			\$ ss insert inner radius
404	pz	201.93			\$ top of water reflector
405	pz	171.4499			\$ top of scrap basket #1
406	pz	115.2525			\$ top of ss plate #1
407	pz	114.3			\$ top of water gap #2
408	pz	111.1377			\$ top of intact fuel #2
409	pz	58.1025			\$ top of ss plate #2
410	pz	57.15			\$ top of water gap #3

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411	pz	53.9877	\$ top of intact fuel	#3
412	pz	0.9525	\$ top of ss plate	#3
413	pz	0.0	\$ top of water gap	#4
414	pz	-3.1623	\$ top of intact fuel	#4
415	pz	-56.1975	\$ top of ss plate	#4
416	pz	-57.15	\$ top of water gap	#5
417	pz	-60.3123	\$ top of intact fuel	#5
418	pz	-113.3475	\$ top of ss plate	#5
419	pz	-114.3	\$ top of scrap basket	#6
420	pz	-170.49749	\$ top of ss plate	#6
421	pz	-171.45	\$ top of ss end cap	
422	pz	-190.5	\$ bottom of ss end cap	
423	pz	-220.98	\$ water below mco	
424	cz	29.21	\$ mco liner	
425	cz	31.75	\$ water gap	

mode n				
kcode	1000	1.0	10	50
ksrc	9.82784	0.0	143.35125	
	-9.82784	0.0	143.35125	
	0.0	9.67545	84.6201	
	0.0	-9.67545	84.6201	
	0.0	9.67545	27.4701	
	0.0	-9.67545	27.4701	
	0.0	9.67545	-29.6799	
	0.0	-9.67545	-29.6799	
	0.0	9.67545	-86.8299	
	0.0	-9.67545	-86.8299	
	9.82784	0.0	-142.39875	
	-9.82784	0.0	-142.39875	
				\$ 12 source points
m1	92235.50c	-0.009471	92238.50c	-0.990529 \$ mkia inners
m2	40000.50c	-1.000		\$ zr clad
m3	6000.50c	-0.0004		\$ stainless steel 304
	25055.50c	-0.0200		\$ (8.03 g/cc)
	14000.50c	-0.0100		
	24000.50c	-0.1900		
	28000.50c	-0.0925		
	26000.55c	-0.6871		
m4	1001.50c	-0.1119	8016.50c	-0.8881 \$ water
mt4	lwtr.01t			
m5	6000.50c	-0.000396		\$ borated stainless steel 304
	25055.50c	-0.0198		\$ (8.03 g/cc)
	14000.50c	-0.0099		
	24000.50c	-0.1881		
	28000.50c	-0.091575		
	26000.55c	-0.680229		
	5010.50c	-0.00199		
	5011.55c	-0.00801		
m6	92235.50c	-0.012491	92238.50c	-0.987509 \$ mkia outers
m7	92235.50c	-0.011494	92238.50c	-0.988506 \$ mkia scrap
m8	7014.50c	-0.80	8016.50c	-0.20 \$ air in gap
totnu				
ctme 350.				
print				

Sample WIMS-E input file

The following is a listing of the input file spr_21, used to vary the spacing of 2.1 wt% enriched SPR fuel in a water lattice:

```
*****
* criticality calculations for spr fuel ...
* dimensions for 1.25 wt% enrichment ...
*****
ncycle 1 11
*
xhead 1
nmesh 20
nregion 5
nmaterial 3
endp
print 0
cent
mesh 4 1 4 1 10
material 1 1.0 296.0 3 3001 11.1 6016 88.9
material 2 2.70 296.0 2 27 100.0
material 3 16.580 296.0 1 2235 2.1 8238 97.9
annulus 1 0.560 1 *inner water region
annulus 2 0.690 2 *inner clad
annulus 3 1.805 3 *fuel
annulus 4 1.910 2 *outer clad
qual 1 1
annulus 5 2.15 1 *cell radius
qual 1 2
annulus 5 2.30 1 *cell radius
qual 1 3
annulus 5 2.45 1 *cell radius
qual 1 4
annulus 5 2.60 1 *cell radius
qual 1 5
annulus 5 2.75 1 *cell radius
qual 1 6
annulus 5 2.90 1 *cell radius
qual 1 7
annulus 5 3.05 1 *cell radius
qual 1 8
annulus 5 3.20 1 *cell radius
qual 1 9
annulus 5 3.35 1 *cell radius
qual 1 10
annulus 5 3.50 1 *cell radius
qual 1 11
annulus 5 3.65 1 *cell radius
begin
*
* pres calculations
*
wpres 1 2
groups 15 27
nuclide 2235 296.
nuclide 8238 296.
print 0
begin
*
* perseus calculations
*
wthes 2
print 0
begin
*
wres 2 3
groups 15 27
nuclide 2235 296.
nuclide 8238 296.
print 0
begin
*
* perseus calculations
*
```

```

wthes      3
print      0
begin
*
wpip       3
print      0
toler 1.0e-5
omega  1.25
begin
*
* collapse to 2 groups
*
wcond      3 4
group      2
endp
part       27 69
begin
*
* smear the cell into one region
*
wsmeas     4 5
mate       1
mesh       1
endp
newmat 1 1 1 2 3 4 5 6 7 8 9 10
          11 12 13 14 15 16 17 18 19 20
mcode      1
begin
*
* print 2-group cross sections save it on unit 7
*
winter     5
print
file       3
matrix
snap
begin
finish
stop

```

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		Date November 7, 1997	
Project Title/Work Order Results for Additional Calculations for Task Order 98-009B-01, Addendum 3 to: HNF-SD-SNF-CSER-005, Revision 3		EDT No. 622985	
		ECN No.	

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